Functional Performance Tests for the Anterior Cruciate Ligament Insufficient Athlete

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Abstract:

Considerable controversy exists regarding the functional assessment of the anterior cruciate ligament (ACL) insufficient athlete. Traditionally, clinicians have speculated that certain physical characteristics, such as muscular strength and power and joint laxity, should be assessed and used to predict functional capacity. Recent research has refuted the relationship between these physical characteristics andfunctional capacity, and has suggested the best assessment of functional capacity is acheived through the use of three functional performance tests. This paper describes three objective functional performance tests (FPTs) that have been shown to be accurate assessments of functional capacity in the A CL insufficient athlete. To assist the clinician with the assessment of the A CL insufficient athlete's readiness to return to pre-injury levels of activity, mean values on three FPTs were established for healthy Division I intercollegiate athletes (n = 30 males, n = 15 females). Collectively, these FPTs provide the clinician with new objective parameters by which to dynamically assess the functional capabilities of the A CL insufficient athlete. The results of these tests help provide a basis for determining an athlete's readiness to return to sport activity.

Article:

Assessment of the anterior cruciate ligament (ACL) insufficient athlete's functional capacity and readiness to return to sport activities remains a controversial and misunderstood issue (2,3,5,9,11). Many suggest the use of various physical characteristics, which are believed to be compensatory for the instability, to assess functional capacity (1,4,8,10,12,13,14). Variables such as thigh musculature strength (4,8,10,12,13), reciprocal muscle group strength ratios (13), static laxity (4,13,14), girth, and range of motion (1) have been traditionally used for assessment of functional capacity in the ACL insufficient athlete.

Recently, the use of such physical characteristics for the assessment of functional capacity has been refuted, based on the lack of a strong relationship between these physical characteristics and functional measures (6). Often the athlete's self assessment and the inappropriate use of these physical characteristics has led to speculative clinical decisions and to the athlete's premature return to sport activity.

The lack of an objective assessment of maneuvers similar to those used in sports participation prompted a recent study that assessed the ACL insufficient athlete's functional level with three functional performance tests (6). These tests included a co-contraction semicircular test, a carioca test, and a shuttle run test. Those ACL insufficient subjects who were able to return to pre-injury levels of sport activity

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performed significantly better on the functional performance tests than those athletes who were unable to return to pre-injury activities. Based on these findings, Lephart et al. suggested that the FPT be included in the battery of assessments used to determine the athlete's readiness to return to functional activity. Furthermore, it was suggested that FPTs may be integrated into the functional rehabilitation phase of the ACL insufficient athlete (6,7).

If the FPTs are to be included in the battery of assessments for returning an ACL insufficient athlete to activity, the clinician must have comparative data available specific to athletes participating in various sports, and in some cases, to positions within sports. The eventual establishment of normative values on the FPTs will provide the injured athlete with the objective goals and more accurate feedback regarding his/her functional status compared to healthy athletes within the same sport. Therefore, this paper describes the functional status of the ACL insufficient athlete, and reports mean values on these tests for healthy athletes specific to gender, sport, and in some instances, positions within sports.

METHODS

Healthy athletes from five intercollegiate men's teams (n = 30, age = 20.3 ± 8 yrs, ht = 6' 1.7" + 3.3", wt =179.2 + 18.3 lbs) and three intercollegiate women's teams (n = 15, age = 19.2 + 1.2 yr, ht = 5' 4.5" + 1.0", wt = 136.7 + 9.9 lbs) at the University of Pittsburgh participated in the study. Male athletes were selected from the football, basketball, baseball, soccer, and gymnastics teams while female athletes were selected from the basketball, volleyball, and gymnastics teams. Football players were divided into two categories: line positions and back positions. The athletes signed an informed consent document, consistent with University policy, to voluntarily participate in the study. The subjects were all familiarized with the test maneuvers and they returned the subsequent day for testing.

FUNCTIONAL PERFORMANCE TESTS

The functional performance tests employed in this study were established to assess functional levels of ACL insufficient athletes. Similar maneuvers are frequently used by clinicians to observe an athlete's functional level. A previous study by Lephart et al. revealed that athletes who returned to pre-injury levels of sport activity performed these tests significantly faster than those athletes who were unable to return to pre-injury levels of sports activity following ACL injury (6).

The functional performance tests attempt to recreate in a controlled environment the forces an athlete experiences during common sport skills/activities. When performed at high speeds, these tests may cause tibial subluxation or the dynamic pivot shift phenomenon in unstable knees. These tests provide an objective measurement of function and include a co-contraction semicircular maneuver, a carioca maneuver, and a shuttle run. Test-retest reliability values for these tests range from r = .92 to r = .96 (6).

The co-contraction test (Figure 1. A, B) was performed by securing a heavy Velcro belt around the athlete's waist, and attaching it to a heavy 48 inch length of rubber tubing with an outer diameter of one inch (Rehab Tubing, Pro Orthopedic Devices, Inc., Tuscon, AZ). The tubing was anchored to a metal loop secured on a wall 60 inches above the floor. A semicircle was painted on the floor which had a radius of 96 inches from the metal loop. The subject stood facing the wall with the toes of his/her feet on the semicircle. This stretched the tubing 48 inches beyond its recoil length. The co- contraction test required each subject to complete five wall- to-wall lengths of the 180° semicircle with the tension applied to the overstretched rubber tubing. The subjects began the test on the right side of the semicircle, moving in a side-step or shuffle fashion, completing the five lengths (three lengths right to left, two lengths left to right) in the minimum amount of time possible.

The carioca test (Figure 2. A, B) required the subjects to move laterally with a crossover step. The test was performed over two lengths of a 40 foot distance. The subjects began moving from left to right, then

reversed direction following the first 40 foot length, thus performing the test moving a total of 80 feet in the minimum amount of time possible.

The shuttle run test, running four lengths of 20 feet (Figure 3), also was performed by the athletes. Each subject ran 20 feet, touched a line on the floor with their foot, reversed direction, then returned to the starting point, touched the line, and repeated the process. The complete test covered 80 feet with three changes in direction.

The criterion for all three tests was elapsed time, measured using a hand-held stop watch. Each subject performed three trials of all tests, and the fastest time was recorded as the score for each of the three tests. The sum of the best time on each test was the total functional performance test (TFPT) score.

Treatment of the data included computation of mean and standard deviation values for each sport and gender for the three functional performance tests and the TFPT. To examine statistically significant differences between sports, an analysis of variance (ANOVA) was performed to determine the significance of differences between the five men's sport teams and the three women's sport teams. A post-hoc Scheffe's F-test was employed to determine the significance ($p < 0.05$) of mean differences between sports.

RESULTS

Mean values on the three functional performance tests and the TFPT are presented in Table 1. Significant mean differences [$F (5, 24) = 5.39$, $p = .002$] for male athletes were revealed for the co-contraction test. The football back and line athletes and the baseball players performed this test significantly faster than the male gymnasts. Among women, basketball players and volleyball players performed the co- contraction test significantly faster [$F (2, 12) = 12.97$, $p = .001$] than gymnasts (Table 1).

Significant mean differences [$F (5,24) = 3.35$, $p = .035$] for the male athletes were also revealed for the carioca test. Football back and line athletes performed the test significantly faster than basketball, gymnastic, and soccer athletes. Among the female athletes, volleyball players had significantly lower times on the carioca test [$F (2, 12) = 7.54$, $p = .008$] than did gymnasts (Table 1).

Significant mean differences [$F (5, 24) = 2.45$, $p. = .062$] were revealed between the football back athletes and the male gymnasts on the shuttle run test. Both the female volleyball players and the female basketball players performed significantly faster [$F (2, 12) = 13. 10$, $p = .00 1$] than female gymnasts on the shuttle run test.

The ANOVA revealed that the football back, football line, and baseball athletes performed all three FPTs (TFPT parameter) significantly faster [$F (5, 24) = 8.47$, $p = .0001$] than male gymnasts. The female basketball and volleyball players performed the FPTs in significantly less time [$F (2, 12) = 16.43$, $p = .0004$] than did the female gymnasts (Table 1).

DISCUSSION

The functional performance tests (FPTs) described in this study have previously been recommended to assess the ACL insufficient athlete's readiness to return to competitive sport activities (6). The three tests selected place critical stress on the knee, while requiring the athlete to demonstrate dynamic control of his/her ACL insufficient knee in order to perform the FPTs at maximum speed.

The co-contraction test was designed to reproduce the rotational forces at the knee necessitating control of tibial translation by the thigh musculature. The carioca crossover maneuver was employed to reproduce the pivot shift phenomenon in the ACL insufficient knee. The shuttle run test was designed to reproduce acceleration and deceleration forces which are common to athletic activity. Typically, a subject with a

dynamically unstable knee will have tibial subluxation, or the sensation of the subluxation, while performing these maneuvers, resulting in apprehension and slower performance of the test.

Our study provided values on the FPTs for 30 healthy collegiate male and 15 healthy collegiate female athletes who participated in various sports. Because of the relatively small number of subjects studied within each sport, the between sport differences are not extremely substantial or meaningful. These preliminary findings suggest that those subjects who participated in sports requiring lateral and running maneuvers

Table 1. Sport specific functional performance test results [Mean (±SD) are in seconds]

SPORT	N	CO-CONTRACTION	CARIOCA	SHUTTLE	TFPT
MEN					
Football Skill	5	9.29 (.64)	5.89 (.35)	6.04 (.31)	21.20 (.94)
Football Line	5	9.63 (.98)	5.54 (.46)	6.29 (.23)	21.47 (1.57)
Basketball	5	10.47 (.35)	6.79 (.54)	6.37 (.11)	23.65 (.87)
Gymnastics	5	11.80 (1.50)	6.70 (1.08)	6.67 (.47)	25.18 (1.61)
Soccer	5	10.21 (.68)	6.44 (.46)	6.28 (.21)	22.94 (1.11)
Baseball	5	9.47 (.76)	5.98 (.43)	6.29 (.29)	21.74 (.64)
TOTAL	30	10.28 (.81)	6.29 (.54)	6.33 (.26)	22.89 (1.19)
WOMEN					
Basketball	5	9.98 (.44)	**7.11 (.23)**	6.81 (.28)	23.91 (.81)
Volleyball	5	10.08 (.15)	6.52 (.41)	6.61 (.26)	23.20 (.71)
Gymnastics	5	12.58 (1.51)	7.59 (.59)	7.68 (.48)	27.85 (2.13)
TOTAL	15	10.88 (.70)	7.07 (.34)	7.03 (.34)	24.98 (1.22)

as a dominant function of their sport, such as basketball and football, perform better on the FPTs that required such maneuvers. Further research may indicate that athletes such as football players, basketball players, and volleyball players may perform faster on these tests simply because of the training adaptations to their particular sport. We encourage other investigators to develop additional functional performance tests specific to such sports as gymnastics, which seldom requires an athlete to cut or to perform crossover maneuvers. Until a substantially larger athlete population can be tested to create normative values within each sport, we suggest the use of preliminary mean scores established by gender as guideline values for assessing performance on the FPTs.

The study, together with a similar study of ACL insufficient athletes (6), provides the clinician with objective tests to determine the true functional level of the ACL insufficient athlete. With the subsequent testing of a larger sample to establish normative values on these FPTs, the clinician will have an improved ability to evaluate the functional status of the ACL insufficient athlete by referring to compiled normative values for healthy athletes classified by gender, by sport, and by position. The results of our study help the clinician to make more objective decisions regarding the ACL insufficient athlete's readiness to return to functional activities. It should help to avoid making premature decisions to return an athlete to sport activity based on the static or open kinetic chain physical characteristics that the athlete possesses.

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